Space Weather Technical Forecast

Issued on Saturday, 12 March 2022 at 13:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Geomagnetic activity expected to increase days 2 and 3 (13th and 14th), with a G1/Minor geomagnetic storm likely. Chance of further M-Class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an M2.3 flare at 11/2232 UTC and several C-class flares observed. These originating mostly from AR2964 in the southwest and AR2965 in the northeast. The long period C2.8 flare from 10th March emitted a large and wide, full halo CME, which is expected to hit Earth either late on 13th March or early on 14th March.

Meanwhile, a CME associated with the aforementioned M2.3 flare, was observed in LASCO C2 and STEREO-A imagery, around 12/2312 UTC, which is still undergoing further analysis for any potential Earth-directed component.

There are currently five numbered sunspot regions on the visible disc, with AR2965 the largest and also magnetically complex, which appears to have shown some growth in its intermediate spots. There are also two other large groups, AR2960 and AR2964. The latter of which is where the M2.3 flare occurred late on 11th and produced the aforementioned CME, which is still being analysed. The remaining sunspots on the visible disc are small, weak and magnetically simple. A new sunspot region has emerged in the northeast quadrant, which has been numbered AR2967 and is a simple Hsx/Alpha.

There are also numerous - mostly small - filaments on the disc at present. The largest of these lifted off the southeastern limb late in the UTC evening of 09 March, with the resultant Coronal Mass Ejection (CME) clearly discernible in coronagraphs. A marginal influence is possible at Earth from at least the shock either late 13th March or more likely through 14th March.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, ranged between background levels and slightly elevated levels, with a peak of 423km/s at 11/2229 UTC. The solar wind density was predominantly at average levels, but with some periods of above average density, especially at the start of the period. The IMF was largely Moderate with a maximum of 12nT at the start of the period. The north-south component fluctuating wildly between weak and moderate throughout and in both positive and negative directions of +10/-10 nT. The phi angle was largely negative (toward the sun), with brief spells of positive (away from the sun) orientations. These parameter fluctuations are implicit of the after effects of the CME arrivals from the 5th and 7th March. Geomagnetic activity was Unsettled to Active (Kp 3-4), with G1/minor storm (Kp 5) observed at 12/0000-0300 UTC in response to the passing of a CME.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was slightly above background levels in response to the CME being emitted from the long period C-class flare from 10th, but remained below the S1 level.
The high energy electron flux (greater than 2 MeV) was Background to Moderate levels, with the

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corresponding 24-hour integrated electron fluence falling below the Active (1e8 integrated pfu) level from 11/1500 UTC after a sustained period above threshold over recent days, with 2.64e6 integrated pfu observed at 12/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with further C-class flares expected and a chance of further M-class flares. The risk being distributed between AR2965 and AR2964, though risks reducing marginally on day 3 (14th) as AR2954 rotates off the disc.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CME's in the forecast. The first is from the 9th March southeast quadrant filament. This may influence Earth either late day 2 (13th) or through day 3 (14th). The large full halo CME, from 10th March has been analysed and is Earth-directed, and is also expected to arrive either late on day 2 (13th) or early on day 3 (14th), and will probably be a larger impact than the 9th March CME. Meanwhile, CH65/- in the west may bring fast wind during day 2 (13th), although this is likely to be absorbed by the large CME, which may also enhance geomagnetic activity.

Geomagnetic activity is expected to trend back to mostly Quiet or Unsettled (Kp1-3) conditions, with a slight chance of further Active intervals on day 1 (12th). During day 2 (13th) activity is likely to increase, becoming generally Unsettled to Active, either under the influence of the 9th March CME, but more likely due to the expected arrival of the 10th March full halo CME. This is likely to give a G1/Minor (Kp 5) Storm late on day 2 or during day 3 (13th or 14th), with a Chance of a G2/Moderate (Kp 6). Geomagnetic activity will then return to largely Quiet to Unsettled (Kp 1-3) from day 4 (15th), with only a slight chance of Active or G1/Minor storm intervals.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at Background levels, albeit with a very slight chance of rising above-the S1 level.

The high energy (greater than 2 MeV) electron flux is currently at Background to Moderate levels, but there is a slight chance of a rebound day 1 (12th), especially at the peak of the diurnal cycles. During days 2 and 3 (13th and 14th), with the likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels. There is a chance during day 4 (15th) electron flux may become active again.

The corresponding fluence will be below the Active levels (1e8 integrated flux) with only a slight chance of increasing above Active levels, mainly day 1 (12th).

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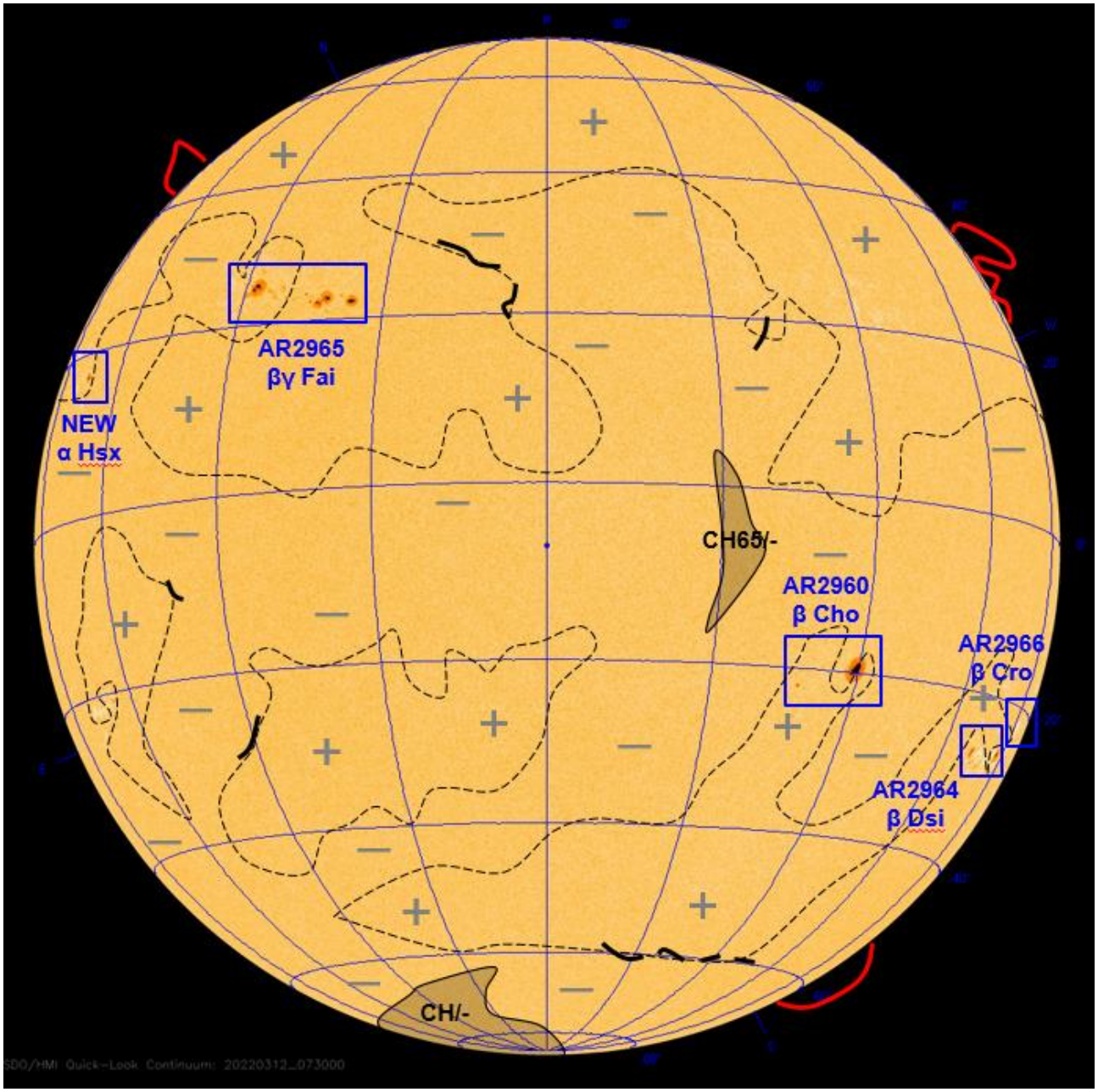
Figure 1. Solar Analysis Valid 12/0730 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two potentially Earth-directed CME's in the forecast. The first is from the 9th March southeast quadrant filament. This may influence Earth either late day 2 (13th) or through day 3 (14th). The large full halo CME from the 10th March has been analysed and is Earth-directed, and is also expected to arrive either late on day 2 (13th) or early on day 3 (14th), and will probably be a larger impact than the 9th March CME. Meanwhile, CH65/- in the west may bring fast wind during day 2 (13th), although this is likely to be absorbed by the large CME, which may also enhance geomagnetic activity. The combination of the arrival of the two CME's and the HSS late on 13th or early 14th is bringing the higher than average risks as displayed in the table above. Day 4 (15th) will then likely see solar winds speeds return to slightly elevated or background levels.

Another CME associated with the aforementioned M2.3 flare from late on the 11th, was observed in LASCO C2 and STEREO-A imagery and is still undergoing further analysis for any potential Earth-directed component.

Geomagnetic activity is expected to trend back to mostly Quiet or Unsettled (Kp1-3) conditions during day 1 (12th), with a chance of further Active intervals. During day 2 (13th) activity is likely to increase, becoming generally Unsettled to Active, either under the influence of the 9th March CME, but more likely due to the expected arrival of March 10th 'full halo' CME. This is likely to give a G1/Minor (Kp 5) Storm late on day 2 or during day 3 (13th or 14th), with a Chance of a G2/Moderate (Kp 6). Geomagnetic activity will then return to largely Quiet to Unsettled (Kp 1-3) conditions from day 4 (15th), with only a slight chance of Active or G1/Minor storm intervals.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	30	70	60	10
Strong	G3	No	1	2	2	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2300	Partial	SE quadrant filament	36E 18S	445km/s	13/2300UTC	Possible shock, mainly outside period. Low.
11/0406	Full	NW quadrant	Approx 11W 23N	577	13/2200UTC (+/-6 hours)	Earth-directed

Figure 2: LASCO-C3 (left) and STEREO-A (right) shows the 'full halo' CME from the 10th March, which is Earth-directed and is forecast to arrive either late on the 13th or early on the 14th March.

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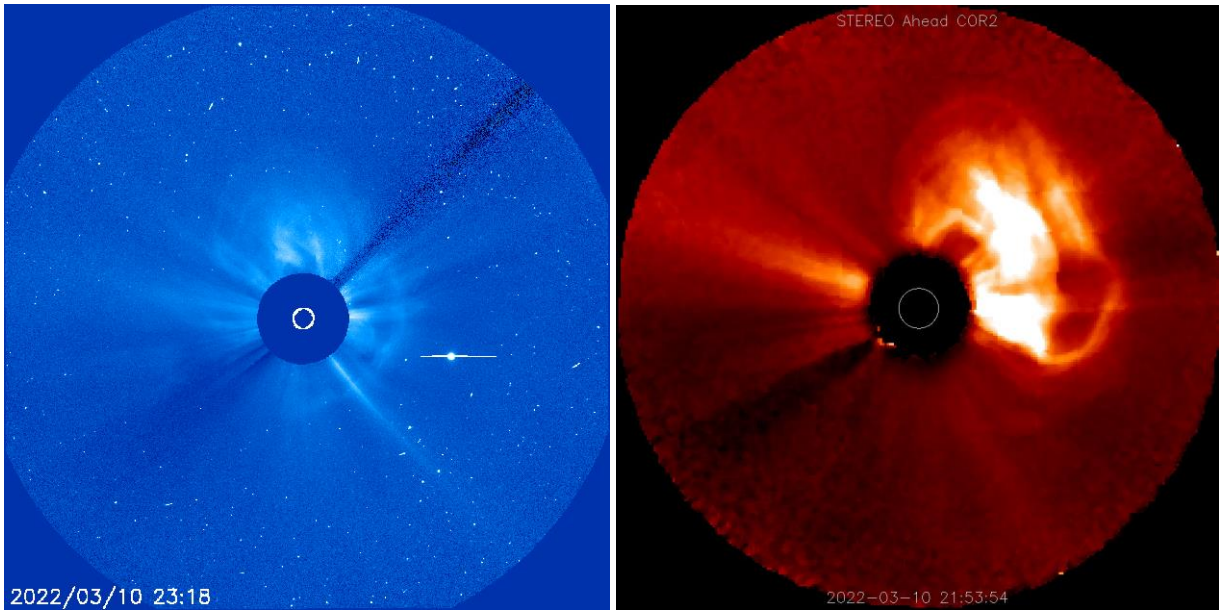
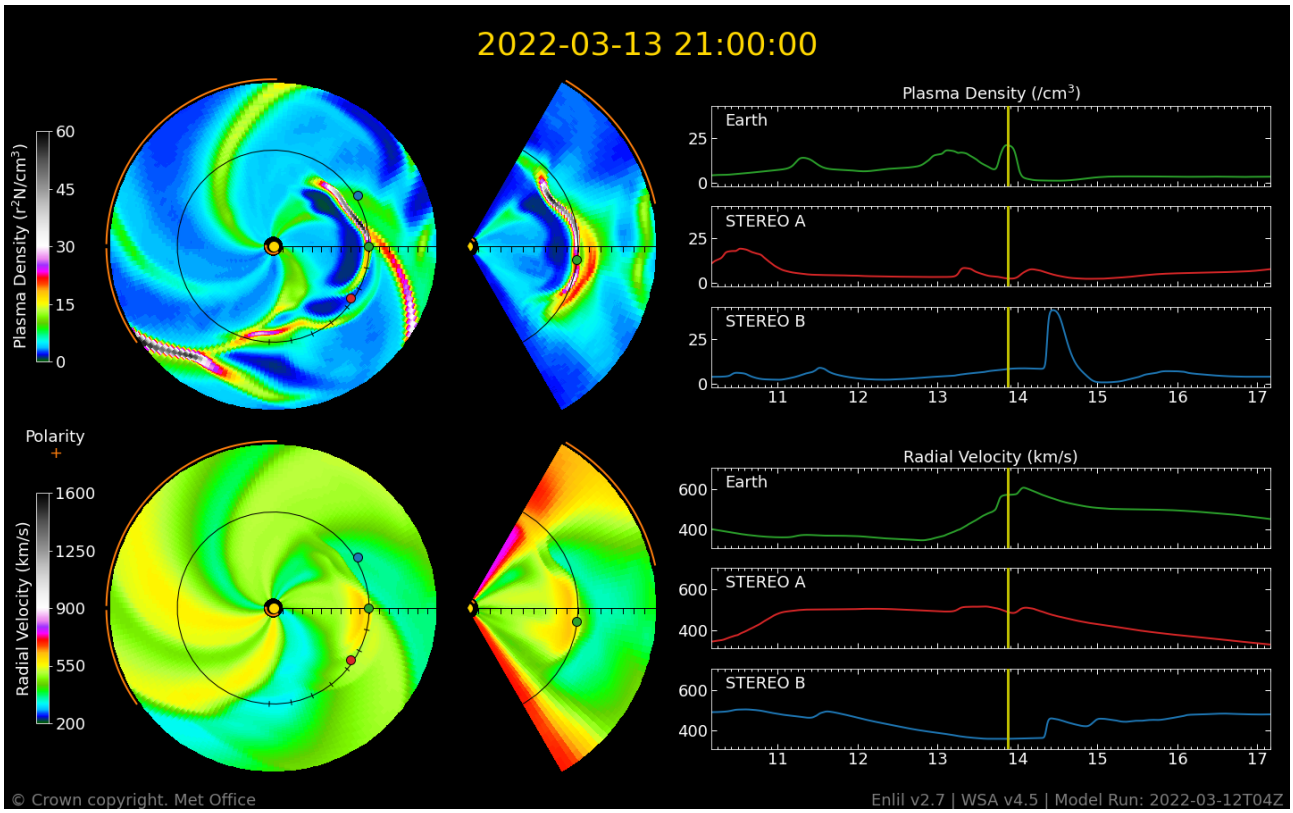


Figure 3: MOSWOC Enlil model shows the arrival of the 10th March CME.



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Radio Blackouts - X-Ray Flares:
There are currently five sunspot regions on the visible disc. AR2964 and AR2966 in the southwest are hard to discern between as they approach the western limb. The more complex of these two (AR2964) is more active and as a result emitted an M-class flare late on the 11th. This produced a CME, which can be clearly seen in coronagraph imagery and is currently undergoing further analysis for any potential Earth-directed component. Given its location in the southwest limb, this may give Earth a glancing blow within the forecast period, or possibly combine with the large 'full halo' from 10th March. Any results will be added in the next update to the guidance. AR2965 in the northwest is by far the most complex and largest but has only produced C-class flares in the past 24 hours. This region will be closely monitored and is partly the reason for the elevated M-class flares risk in the forecast above. From day 3 (14th) this will be the only region possibly producing M-class flares as AR2964 rotates around the western limb and out of sight, therefore the M-class flare risk likely to reduce.

AR2960 is continuing to simplify but remains a large but stable region. All other small spots/pores are simple and pose very little risk to this forecast period at present.
Newly numbered AR2967 has rotated onto the northeast limb, which is currently a simple Hsx/Alpha.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	20	20
Very Active	R3 to R5 X Class	No	2	2	1	1

Figure 4: STEREO-A (left) and LASCO-C3 (right) shows a CME associated with the M2 flare from AR2964 late on the 11th March – still undergoing analysis.

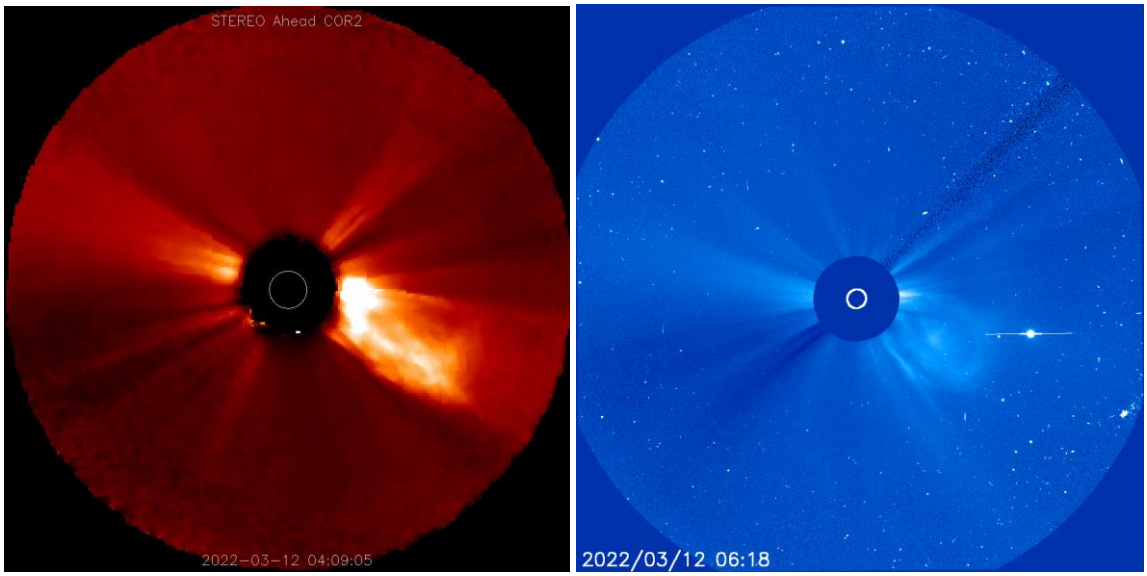

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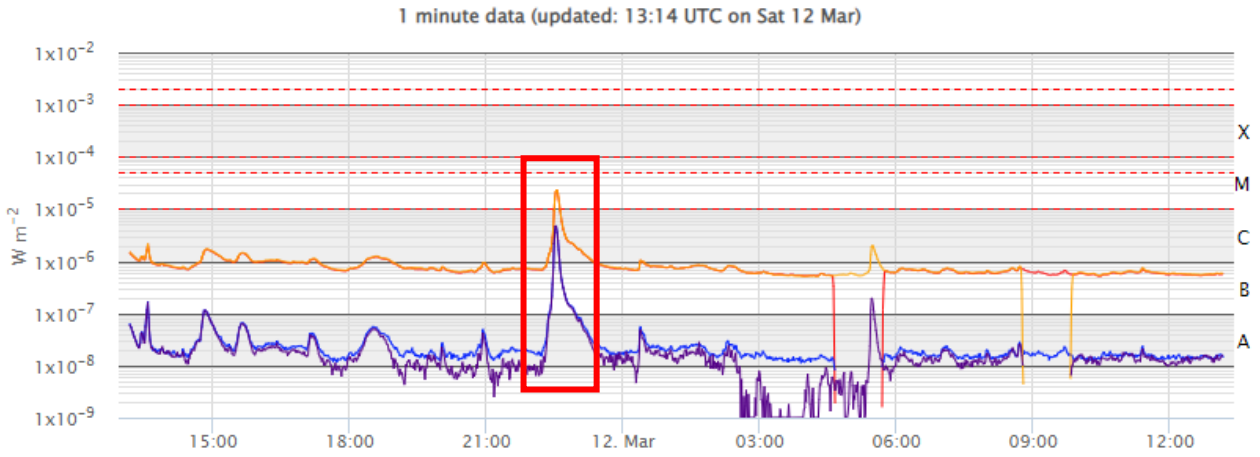
Figure 5: GOES-16 X-Ray flares – shows the M2.3 flare from AR2964



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently slightly elevated, under the residual influence of the CME that was emitted yesterday evening. The high energy proton flux is expected to return and then remain predominantly at background levels, albeit with a slight chance of rising above-the S1 level.

The probabilities have been increased very slightly to reflect the potential of a further large CME, either from the northwest quadrant again or from one of the large and complex sunspot regions on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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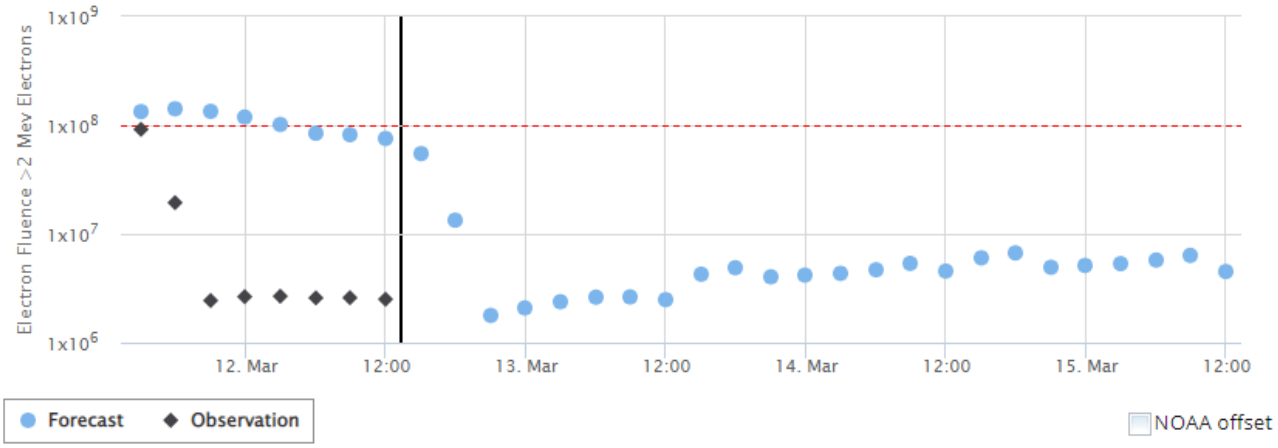
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux is currently at Background to Moderate levels, but there is a chance of a rebound on day 1 (12th), especially at the peak of the diurnal cycle. Low confidence. During days 2 and 3 (13th and 14th), with the likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels. There is a chance during day 4 (15th) electron flux may become active again.

The corresponding fluence will be below the Active levels (1e8 integrated flux) with only a slight chance of increasing above Active levels, mainly day 1 (12th).

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	30	20	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: Met Office REFM electron fluence observations and forecast.



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